PHSX 491: General Relativity Spring 2017

PROFESSORS:	Dr. Alex Bulmahn	Dr. Nate McCrady
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OFFICE HOURS:	MW 10-11:30 and by appt	TuTh 11-12, F 1-2 and by appt
LECTURE:	MWF 2-2:50 pm, CHCB 231	
TEXTBOOK:	*A General Relativity Workbook,* by Thomas A. Moore	
PREREQUISITES:	Special relativity (PHSX 141 or PHSX 343), linear algebra (M 221 or PHSX 301)	

Overview

General relativity is the classical theory of gravity. Formulated by Albert Einstein, it builds upon the revolutionary concept that gravity is not actually a force, but rather the result of the curvature of four-dimensional *spacetime*. Gravity *is* geometry: mass curves spacetime in its vicinity, and all masses follow straight-line trajectories (called *geodesics*) through curved spacetime. General relativity is central to our understanding of neutron stars, black holes, gravitational lensing of light, gravitational waves, and the structure and time evolution of the Universe. In this course, we will develop the mathematics necessary for general relativity, and apply the theory to physical problems in regions of extreme gravity.

Learning Objectives

Upon completion of this course you should have gained an understanding of:

- tensor mathematics and index notation.
- the Einstein Equation: $\mathbf{G}^{\mu\nu} = 8\pi G\, \mathbf{T}^{\mu\nu}$
- gravity as a manifestation of the geometry of spacetime.
- application of general relativity to solve physical problems.

Grading

Your grade for the course will be based on weekly homework assignments, two in-class midterm exams, and a final exam. **Homework is due at 5 pm on the due date (generally Mondays) and late homework will be penalized 10% per day late (not including weekends and holidays). Make up exams will only be given in extreme circumstances.**

Grading for the course will be broken down as follows:

Homework:	40%
Midterm Exams:	17.5% each (35% total)
Final Exam:	25%

This course may only be taken with the traditional grading option. The letter grades in this course will be determined by the performance of the class as a whole, but we do not have a set number of A's, B's, etc. predetermined. You will get the grade that you earn.

Note: the last day to drop the course via Cyberbear is February 10th. The last day to drop the course without the Dean's signature is April 3rd.

Expectations of the Professors

Time in the classroom is an essential part of this course, and it will be to your benefit to attend lectures. Exams and homework will be based primarily on material presented in class. The readings from the textbook, in particular the "boxes" in the workbook, will help you prepare for class meetings. This syllabus includes the assigned readings. *We expect students to read the material in advance of the class on the topic, and to be prepared to discuss the material in class.*

This course is a collaborative effort – please ask questions, offer your ideas and be prepared to participate in the discussion. Written work submitted in this course must be expressed in your own words. We specifically encourage students to work together, but each student must write up her/his own response to problems. This step is essential to your learning – writing up the answer to a question requires you to understand the conclusion of your group, whereas transcription of the work of another does not. When in doubt, please check with us.

Course Guidelines and Policies

Student Conduct Code

The Student Conduct Code at the University of Montana embodies and promotes honesty, integrity, accountability, rights, and responsibilities associated with constructive citizenship in our academic community. This Code describes expected standards of behavior for all students, including academic conduct and general conduct, and it outlines students' rights, responsibilities, and the campus processes for adjudicating alleged violations. Full student conduct code. (http://www.umt.edu/vpsa/policies/student_conduct.php)

Disability Modifications

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students. . https://www.umt.edu/dss/default.php If you think you may have a disability adversely affecting your academic performance, and you have not already registered with Disability Services, please contact Disability Services in Lommasson Center 154 or call 406.243.2243. I will work with you and Disability Services to provide an appropriate modification.

Tentative Schedule

Dates	Topic	Reading /Notes
1/23—27	Special Relativity	Ch 1, 2
1/30—2/3	Four Vectors, Index Notation	Ch 3, 4
2/6—17	Coordinate Systems, Tensors, Geodesics	Ch 5, 6, 8
2/22—24	Schwarzschild Metric	Ch 9 **Midterm Exam #1**
2/27—3/6	Particle Orbits, Precession of Perihelion	Ch 10, 11
3/8—17	Photon Orbits, Event Horizon	Ch 12, 14
3/20—24	*Spring Break*	
3/27—4/3	The Calculus of Curvature	Ch 17, 18
4/5—10	Riemann Tensor, Stress-Energy Tensor	Ch 19, 20
4/12—19	The Einstein Equation	Ch 21, 22 **Midterm Exam #2**
4/21—5/5	Application of GR (Topic TBD)	
5/8—12	**Finals Week** **Final Exam 3:20-5:20 pm, Wednesday 5/10**	**Exam in 231 CHCB**